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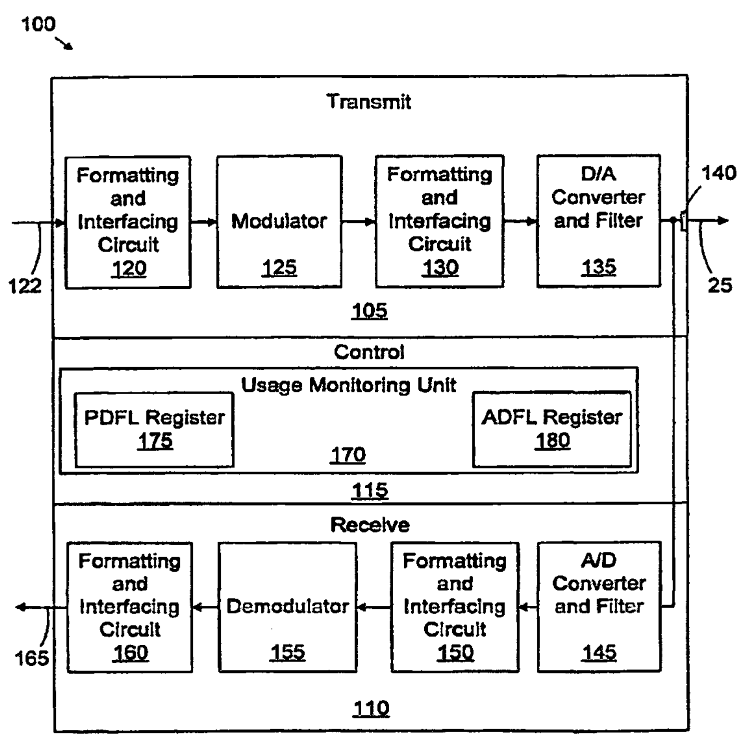
(54) Title: TRANSCEIVER WITH USAGE-BASED RATE ADAPTATION FOR ADSL MODEM

(57) Abstract

A transceiver (100) includes a receive unit (110) and a usage monitoring unit (170). The receive unit (110) is adapted to receive data at a maximum dataflow rate. The data includes actual data and idle cell data. The usage monitoring unit (170) is adapted to determine a usage parameter based on the actual data and adjust the maximum dataflow rate based on the usage parameter. A method for adjusting a maximum dataflow rate of a transceiver (100) is provided. The method includes receiving data. The data includes actual data and idle cell data. A usage parameter is determined based on the actual data. The maximum dataflow rate is adjusted based on the usage parameter.



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TRANSCEIVER WITH USAGE-BASED RATE ADAPTATION FOR ADSL MODEM

TECHNICAL FIELD

This invention relates generally to communication systems, and, more particularly, to a transceiver with usage-based rate adaptation.

BACKGROUND ART

In communications systems, particularly telephony, it is common practice to transmit signals between a subscriber station and a central switching office via a two-wire bi-directional communication channel. The Plain Old Telephone System (POTS), designed primarily for voice communication, provides an inadequate data transmission rate for many modem applications. To meet the demand for high-speed communications, designers have sought innovative and cost-effective solutions that take advantage of the existing network infrastructure. Several technological advancements have been proposed in the telecommunications industry that make use of the existing network of telephone wires. One of these technologies is the xDSL technology. DSL technology uses the existing network of telephone lines for broadband communications. An ordinary twisted pair equipped with DSL interfaces can transmit videos, television, and high-speed data.

DSL technologies leave the POTS service undisturbed. Traditional analog voice band interfaces use the same frequency band, 0-4 Kilohertz (kHz), as telephone service, thereby preventing concurrent voice and data use. A DSL interface, on the other hand, operates at frequencies above the voice channels from 100 kHz to 1.1 Megahertz (MHz). Thus, a single DSL line is capable of offering simultaneous channels for voice and data.

DSL systems use digital signal processing (DSP) to increase throughput and signal quality through common copper telephone wire. Certain DSL systems provide a downstream data transfer rate from the DSL Point-of-Presence (POP) to the subscriber location at speeds of about 1.5 Megabits per second (MBPS). The transfer rate of 1.5 MBPS, for instance, is fifty times faster than a conventional 28.8 kilobits per second (KBPS) transfer rate.

One popular version of the DSL technology is the Asymmetrical Digital Subscriber Line (ADSL) technology. The ADSL standard is described in ANSI T1.413 Issue 2, entitled, "Interface Between Networks and Customer Installation - Asymmetric Digital Subscriber Line (ADSL) Metallic Interface, Rev. R4, dated 6/12/98.

ADSL modems use two competing modulation schemes: discrete multi-tone (DMT) and carrierless amplitude/phase modulation (CAP). DMT is the standard adopted by the American National Standards Institute. The technology employed by DMT ADSL modems is termed discrete multi-tone. The standard defines 256 discrete tones. Each tone represents a carrier signal that can be modulated with a digital signal for transmitting data. The specific frequency for a given tone is 4.3125 kHz times the tone number. Tones 1-7 are reserved for voice band and guard band (*i.e.*, tone 1 is the voice band and tones 2-7 are guard bands). Data is not transmitted near the voice band to allow for simultaneous voice and data transmission on a single line. The guard band helps isolate the voice band from the ADSL data bands. Typically, a splitter may be used to isolate any voice band signal from the data tones. Tones 8-32 are used to transmit data upstream (*i.e.*, from the user), and tones 33-256 are used to transmit data downstream (*i.e.*, to the user). Alternatively, all the data tones 8-256 may be used for downstream data, and upstream data present on tones 8-32 would be detected using echo cancellation. Because more tones are used for downstream communication than for upstream communication, the transfer is said to be asymmetric.

Through a training procedure, the modems on both sides of the connection sense and analyze which tones are less affected by impairments in the telephone line. Each tone that is accepted is used to carry information. Accordingly, the maximum capacity is set by the quality of the telephone connection. The maximum data rate defined by the ADSL specification, assuming all tones are used, is about 8 MBPS downstream and about 640 KBPS upstream.

In present ADSL implementations, bits are allocated to different carriers according to a "loading" algorithm, such as the Water Filling (WF) algorithm or Equal Energy Distribution (EED) algorithm, for example. The aforementioned loading algorithms utilize the signal-to-noise ratio (SNR) profile of a channel and a desired SNR margin to allocate bits. In general, carriers with higher SNR are able to carry more bits than those with lower SNR values. Typically, increasing the desired margin reduces the number of bits that can be carried by a given carrier. These loading algorithms typically attempt to establish either a maximum throughput or start with a predetermined throughput and distribute the bits required to support that throughput to the least impaired tones. After the modem has been trained, dynamic rate adaptation or bit swapping techniques may be used to change the bit rate in response to improving or degrading line conditions.

Current bit loading techniques suffer from at least one disadvantage in that they strive to maximize throughput at the expense of processing resources and power. To support higher data transmission rates, these modems employ powerful, but computationally taxing, algorithms, such as Trellis Coded Modulation (TCM), for example. These bit loading techniques account for variable line conditions, but do not consider the real-time, changing needs of the user. In cases where a user is not fully-utilizing the allocated bandwidth, idle cells are inserted to bring the overall data rate up to the current capacity. Idle cells are removed at the receiving end, but they still require the same amount of processing as user data at the transmitting end. This leads to unnecessary power and processing resource usage. Also, in applications where modems are shared among multiple users (*i.e.*, a central office modem may support multiple connections), the use of a throughput-maximizing loading technique results in a need for increased processing power, and as a result, increased hardware requirements.

The present invention is directed to overcoming, or at least reducing the effects of, one or more of the problems set forth above.

DISCLOSURE OF INVENTION

One aspect of the present invention is seen in a transceiver including a receive unit and a usage monitoring unit. The receive unit is adapted to receive data at a maximum dataflow rate. The data includes actual data and idle cell data. The usage monitoring unit is adapted to determine a usage parameter based on the actual data and adjust the maximum dataflow rate based on the usage parameter.

In another aspect of the present invention, a method is provided for adjusting a maximum dataflow rate of a transceiver. The method includes receiving data. The data includes actual data and idle cell data. A usage parameter is determined based on the actual data. The maximum dataflow rate is adjusted based on the usage parameter.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be understood by reference to the following description taken in conjunction with the accompanying drawings, in which like reference numerals identify like elements, and in which:

Figure 1 is a block diagram of a communications system in accordance with the present invention;

Figure 2 is a simplified block diagram of a modem in accordance with the present invention; and

Figure 3 is a state diagram of a bit loading state machine for controlling the bit loading of data received by the modem of Figure 2.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

MODE(S) FOR CARRYING OUT THE INVENTION

Illustrative embodiments of the invention are described below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

Referring to Figure 1, a block diagram of a communications system 10 is provided. The communications system 10 includes a first modem 15 coupled to a second modem 20 through a connection 25. In the illustrated embodiment, the second modem is part of a central office 30, and the connection 25 is an ordinary twisted pair connection, as is common in present-day telephone networks. However, other connection types are contemplated, depending on the specific implementation. Also, it is contemplated that the second modem 20 may not be part of the central office 30. For purposes of illustration, the modems 15, 20 are described as they might be implemented under the ADSL protocol (ANSI T1.413 Issue 2, entitled, "Interface Between Networks and Customer Installation - Asymmetric Digital Subscriber Line (ADSL) Metallic Interface, Rev. R4, dated 6/12/98). It is contemplated that the techniques described herein may be applied to other communication protocols, depending on the specific implementation.

In the illustrated embodiment, the second modem 20 acts as a gateway to a larger communications network (not shown), such as a local or wide area network, or the Internet. Typically, the first modem 15 establishes a connection to the communications network (not shown) through the second modem 20. During the process of establishing the connection, the first and second modems 15 and 20 complete a training process whereby an initial bit loading technique (*e.g.*, water filling, equal energy distribution, *etc.*) is employed to establish the throughput available for communication between the modems 15, 20.

Although the present invention is described as it may be implemented in a modem, it is contemplated that, in light of this disclosure, the invention may be applied to any type of transceiver, including, but not limited to, a modem or some other wired or wireless communication device.

After training, data exchange between the modems 15, 20 commences. Over time, one or both of the modems 15, 20 may monitor the transfer rate and adjust the bit loading in response to the dynamic throughput requirements. For purposes of illustration, the throughput monitoring and adjustment is described as if the first modem 15 is monitoring the rate at which it receives data from the second modem 20. However, it is contemplated that either or both of the modems 15, 20 may cooperatively or independently monitor and adjust the throughput.

Referring to Figure 2, a simplified block diagram of a modem 100 is provided. The modem 100 may be the first modem 15 or the second modem 20. For clarity and ease of illustration, not all functional blocks are

illustrated in detail, because these items are known to those of ordinary skill in the art, and are further defined in well known modem standards.

The modem 100 includes transmit, receive, and control functional blocks 105, 110, 115. The transmit block 105 includes a formatting and interfacing circuit 120 adapted to receive outgoing digital data over a data-out line 122. The formatting and interfacing circuit 120 performs functions such as cyclic redundancy checking (CRC), scrambling, forward error correction, and interleaving. As stated above, these functions are known to those of ordinary skill in the art. The transmit block 105 also includes a modulator 125 that receives data from the formatting and interfacing circuit 120 and modulates a carrier or carriers with the data. The modulator 125 performs tone ordering, constellation encoding, gain scaling, and an inverse discrete Fourier transform (IDFT) function to provide time domain waveform samples. A second formatting and interfacing circuit 130 performs cyclic prefix insertion (*i.e.*, a subset of the output samples from the modulator 125 is replicated and prepended to the existing output samples to provide an overlap and allow for better frame alignment) and buffers the samples received from the modulator 125. A digital to analog (D/A) converter and filter 135 converts the samples from the formatting and interfacing circuit 130 to an analog waveform suitable for transmission over the connection 25 through an external line interface 140.

The receive block 110 includes an analog to digital (A/D) converter and filter 145 that receives an analog waveform over the connection 25 and samples the analog waveform to generate a time domain digital signal. A formatting and interfacing circuit 150 performs functions known in the art, such as frame alignment and time domain equalization. In time domain equalization, because the tones are at different frequencies, certain frequencies travel faster than others, and as such, all the tones do not arrive at same time. The time domain equalization function of the formatting and interfacing circuit 150 delays the faster tones to compensate for the propagation speed differences. There is a performance trade off between the frame alignment and time domain equalization functions in that a higher degree of frame alignment accuracy allows a lesser degree of accuracy in time domain equalization. The cyclic prefix insertion performed by the interfacing modem (not shown) improves frame alignment accuracy. The formatting and interfacing circuit 150 also performs gain control to increase the amplitude of the received signal.

A demodulator 155 receives the time domain samples from the formatting and interfacing circuit 150 and converts the time domain data to frequency domain data. The demodulator 155 performs a slicing function to determine constellation points from the constellation encoded data, a demapping function to map the identified constellation point back to bits, and a decoding function (*e.g.*, Viterbi decoding if trellis constellation coding is employed). In the case where the modem operates using the ADSL protocol, the demodulator 155 also performs tone deordering to reassemble the serial bytes that were divided among the available tones. A second formatting and interfacing circuit 160 in the receive block 110 performs forward error correction, CRC checking, and descrambling functions on the data received from the demodulator 155. The reconstructed data provided by the formatting and interfacing circuit 160 represents the sequential binary data that was sent by the interfacing modem (not shown). The reconstructed data is provided to a data-in line 165.

The control block 115 includes a usage monitoring unit 170 adapted to monitor the peak and average dataflows of the data received by the receive block 110. The usage monitoring unit 170 includes a peak dataflow (PDFL) register 175 and an average dataflow (ADFL) register 180. The average dataflow may be measured by the usage monitoring unit 170 using a fixed interval average (*e.g.*, a rolling five minute average). The specific amount of usage history used to generate the average dataflow is application specific, and may be configurable by the user

or the central office 30. The data received by the receive block 110 includes actual data and idle cells. the idle cells are used by the transmitting modem (not shown) to load the tones to capacity. The receive block 110 discards the idle cells after receiving the data. The usage monitoring unit 170 determines the average and peak dataflows based on the actual data (*i.e.*, after the idle cells have been removed).

The operation of the usage monitoring unit 170 is illustrated using the diagram of a bit loading state machine 200 depicted in Figure 3. The state machine 200 is entered in an establish data flow state 205. The initial dataflow parameters are established during the training of the modem 100 using a bit loading pattern, such as, but not limited to a water filling algorithm or an equal energy distribution algorithm. The number of bits allocated to the tones determines the maximum dataflow capacity. The state machine 200 transitions from the establish data flow state 205 to a monitor dataflow state 210 when training of the modem 100 has completed.

In the monitor dataflow state 210, the usage monitoring unit 170 populates the PDFL register 175 and the ADFL register 180 based on the dataflow of the received data. It is contemplated that the PDFL register 175 may include the actual peak dataflow or, alternatively, the number of times in the current interval that the peak dataflow reaches the maximum dataflow. If the average dataflow over a monitoring period (*e.g.*, five minutes) exceeds a threshold, such as, for example 70% of the maximum dataflow, the state machine 200 transitions to a increase bits state 215 where the maximum throughput is adjusted by increasing the number of bits on a tone or a number of tones. The method used to increase the number of bits to accomplish the dataflow adjustment is described below.

The state machine 200 may also transition to the increase bits state 215 if the peak dataflow is at the maximum dataflow for a predetermined time interval. For example, the peak dataflow reaches the maximum dataflow for three seconds. Alternatively, it is contemplated that the state machine 200 may transition to the increase bits state 215 if the peak dataflow reaches the maximum dataflow a predetermined number of times during the monitoring interval (*i.e.*, 20 times in five minutes). The thresholds described herein are provided for illustrative purposes. Various thresholding techniques are contemplated depending on the specific implementation.

After increasing the number of bits, the state machine 200 transitions back to the monitor dataflow state 210, and the usage monitoring unit 170 repopulates the PDFL register 175 and the ADFL register 180 under the new operating conditions. If the peak or average dataflows again reach threshold levels, the state machine 200 may return to the increase bits state 215 to further increase the dataflow.

The usage monitoring unit 170 may also reduce the maximum dataflow if the user demand does not require such a bandwidth. If the average dataflow falls below a threshold, such as, for example 40% of the maximum dataflow for the monitoring interval, the state machine 200 transitions to a decrease bits state 220 where the maximum throughput is adjusted by decreasing the number of bits on a tone or a number of tones. Again, the method used to decrease the number of bits to accomplish the dataflow adjustment is described below.

The state machine 200 may also transition to the decrease bits state 220 if the peak dataflow is less than 90% of the maximum dataflow over the monitoring interval. Alternatively, if the peak dataflow reaches the maximum dataflow less than ten times in five minutes, the number of bits may be reduced. Again, the thresholds described herein are provided for illustrative purposes. Various thresholding techniques are contemplated depending on the specific implementation.

In certain circumstances (*i.e.*, large dataflow mismatch), the usage monitoring unit 170 may choose to re-train the connection with a requested bit rate based on the values stored in the usage monitoring unit 170 and the PDFL register 175. In such a case, the state machine 200 transitions to a retrain state 230. Instead of using the

normal bit loading algorithm, the modem 100 will attempt to train with the requested bit rate and restart the state machine 200 at the establish data flow state 205.

As defined in the ADSL standard, the modem 100 may change the number of bits by issuing a bit swap request over the ADSL overhead channel (aoc). Typically, a bit swap request is initiated in response to a change in the operating characteristics of the line (*e.g.*, increase or decrease in impairments). In the illustrated embodiment, the usage monitoring unit 170 may issue a bit swap to increase or decrease the number of bits in response to the peak and average dataflow parameters. Alternatively, using a dynamic rate adaptation configuration request message, the entire bit loading and gain tables used to configure the allocation of bits to all of the tones may be modified and sent by the modem 100 to change the dataflow rate. Per the ADSL standard, DRA reconfiguration messages may also be sent using the aoc channel.

Consider the case where the modem 15 is monitoring the rate at which it receives data from the modem 20 at the central office 30. As requested by the usage monitoring unit 170, the modem 15 sends a bit swap request message to the modem 20 to increase or decrease the number of bits for a particular tone. An aoc message includes a message header (*i.e.*, 11111111) that signals the modem 20 of the impending aoc message. The message header is followed by an 8-bit command field. Per the ADSL standard, a command field value of 00000001 designates increasing the number of allocated bits by one and a command field value of 00000010 designates decreasing the number of allocated bits by one. The command field is followed by an 8-bit tone index designating the particular tone for which to change the number of bits.

The ADSL standard also defines an extended bit swap request where the number of bits for a plurality of channels can be changed simultaneously. The extended bit swap request message includes a message header of 11111100. Six command field and tone index pairs are transmitted to designate the type of change and the particular tone.

The bit swap request message (*i.e.*, normal or extended) is repeated by the modem 15 five times. Within 400 ms of receiving the bit swap request, the modem 20 at the central office 30 responds with a bit swap acknowledge message that includes a message header (*e.g.*, 11111111), an acknowledge command (*e.g.*, 11111111), and a super frame counter number at which the bit swap will be implemented.

The choice of the particular tones on which to change the number of bits depends on the current operating conditions of the modem 100. For example, the usage monitoring unit 170 may choose to lower the number of bits on the more encumbered tones, or raise the number of bits on less encumbered tones.

As stated above, either or both modems 15, 20 may independently monitor the rate at which data is received. The modem 15 may increase an increase in its dataflow at the same time the modem 20 requests a dataflow decrease.

In the cases described above, the adaptive bit rate is limited on the top end by the characteristics of the connection (*i.e.*, the signal to noise ratio, desired margin for error rate, etc.). However, by decreasing the bit rate to match the required dataflow, numerous advantages may be gained. As the number of bits per tone is reduced, the signal to noise margin is increased, and as a result, the error rate is decreased. Also, due to the lower number of bits, the power required to transmit the tones may be reduced. Still more efficiency may be gained by simplifying the modulation scheme in response to the lower dataflow. For example, if the dataflow is sufficiently low, the interfacing modem may not be required to use constellation encoding and/or trellis coding to increase the bit rate. As a result the modem 100 receiving the data would not be required to use a complex decoding method, such as Viterbi.

The decrease in complexity results in lower power and processing resource requirements, thereby increasing the efficiency of the communication. This could increase the battery life in a portable computer (not shown) using the modem 100, or could allow for increased modem sharing for the modem 20 in the central office 30.

Referring to Figure 4, a simplified block diagram of a computer system 300 is provided. The computer system 300 includes a computer 305 coupled to a modem 310. The modem 305 may be external to the computer 305, as illustrated, or alternatively, the modem 310 may be installed as an internal component of the computer 305. The modem 305 operates in a similar manner to the modem 100 described above in reference to Figure 2, except that, in the embodiment of Figure 4, the computer 305 contains a usage monitoring unit 315 for monitoring the dataflow rate of the data received by the modem 310. The usage monitoring unit 315 includes a peak dataflow register 320 and an average dataflow register 325 that are used in a similar manner as described above in reference to the modem 100 of Figure 2. The computer 305 includes software that performs the usage monitoring and rate adaptation functions. The peak and average dataflow registers 320, 325 may be general purpose registers or memory locations within the computer 305. The computer 305 may instruct the modem 315 to adjust its bit rate or retrain based on the usage parameters determined by the usage monitoring unit 315.

The particular embodiments disclosed above are illustrative only, as the invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the invention. Accordingly, the protection sought herein is as set forth in the claims below.

CLAIMS

1. A transceiver (100), comprising:

a receive unit (110) adapted to receive data at a maximum dataflow rate, the data including actual data and idle cell data; and

a usage monitoring unit (170) adapted to determine a usage parameter based on the actual data and adjust the maximum dataflow rate based on the usage parameter.

2. The transceiver (100) of claim 1, wherein the usage parameter comprises at least one of an average dataflow rate of the actual data, a peak dataflow rate of the actual data, and a count indicating the number of times the peak dataflow rate reaches the maximum dataflow rate.

3. The transceiver (100) of claim 1, wherein the receive unit (110) is adapted to receive the data using a plurality of tones, each tone having a zero or positive number of allocated bits, wherein the maximum dataflow rate depends on the number of allocated bits associated with each tone.

4. The transceiver (100) of claim 3, wherein the usage monitoring unit (170) is adapted to change the number of allocated bits associated with at least one of the tones in response to the usage parameter.

5. The transceiver (100) of claim 1, wherein the usage monitoring unit (170) is adapted to adjust the maximum dataflow rate using a bit loading pattern, the bit loading pattern being based on the usage parameter.

6. A communications system (10), comprising:

a first modem (15) adapted to transmit data at a first maximum dataflow rate, the data including actual data and idle cell data;

a second modem (20) coupled to the first modem (15) and adapted to receive the data, the second modem (20) including:

a usage monitoring unit (170) adapted to determine a usage parameter based on the actual data and adjust the maximum dataflow rate based on the usage parameter.

7. The communications system (10) of claim 6, wherein the usage monitoring unit (170) is adapted to adjust the maximum dataflow rate by retraining the first modem (15) using a bit loading pattern, the bit loading pattern being based on the usage parameter.

8. A method for adjusting a maximum dataflow rate of a transceiver (100), comprising:

receiving data, the data including actual data and idle cell data;

determining a usage parameter based on the actual data; and

adjusting the maximum dataflow rate based on the usage parameter.

9. The method of claim 8, wherein determining the usage parameter comprises determining at least one of an average dataflow rate of the actual data, a peak dataflow rate of the actual data, and a count indicating the number of times the peak dataflow rate reaches the maximum dataflow rate.

10. The method of claim 8, wherein receiving the data comprises receiving the data using a plurality of tones, each tone has a zero or positive number of allocated bits, and the maximum dataflow rate depends on the number of allocated bits associated with each tone.

11. The method of claim 10, wherein adjusting the maximum dataflow rate comprises changing the number of allocated bits associated with at least one of the tones in response to the usage parameter.

12. The method of claim 8, wherein adjusting the maximum dataflow rate comprises adjusting the maximum dataflow rate using a bit loading pattern, the bit loading pattern being based on the usage parameter.

13. The method of claim 8, wherein adjusting the maximum dataflow rate comprises retraining the transceiver (100) to set the maximum dataflow rate based on the usage parameter.

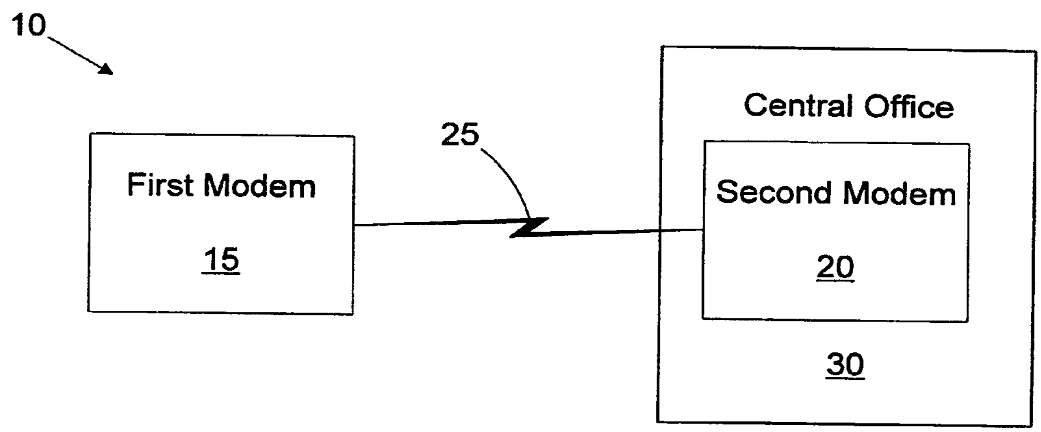

Figure 1

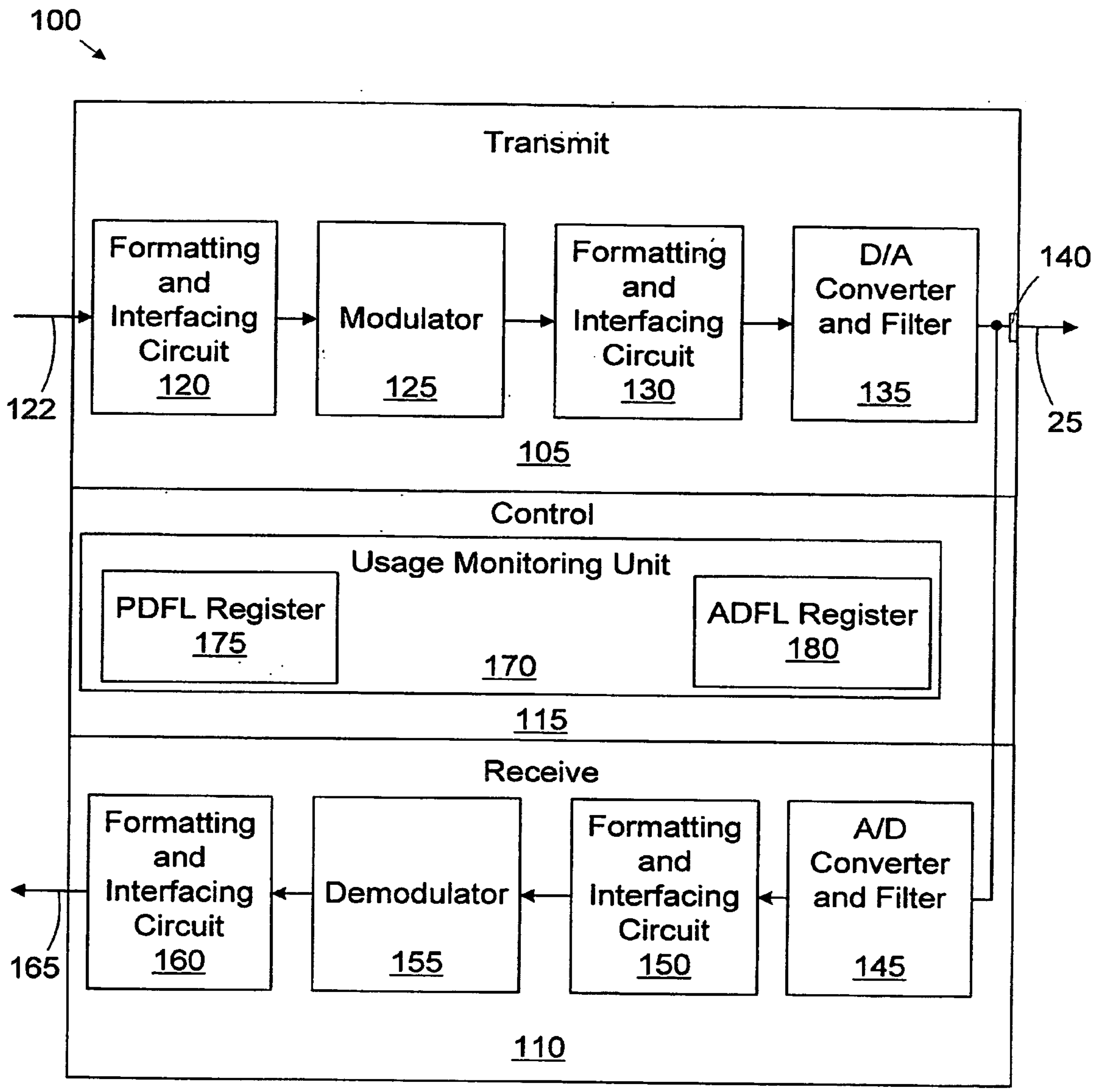
100
Transmit
Formatting and Interfacing Circuit 120
Modulator 125
Formatting and Interfacing Circuit 130
D/A Converter and Filter 135
140
122
25
105
Control
Usage Monitoring Unit
PDFL Register 175
170
ADFL Register 180
115
Receive
Formatting and Interfacing Circuit 160
Demodulator 155
Formatting and Interfacing Circuit 150
A/D Converter and Filter 145
165
110

Figure 2

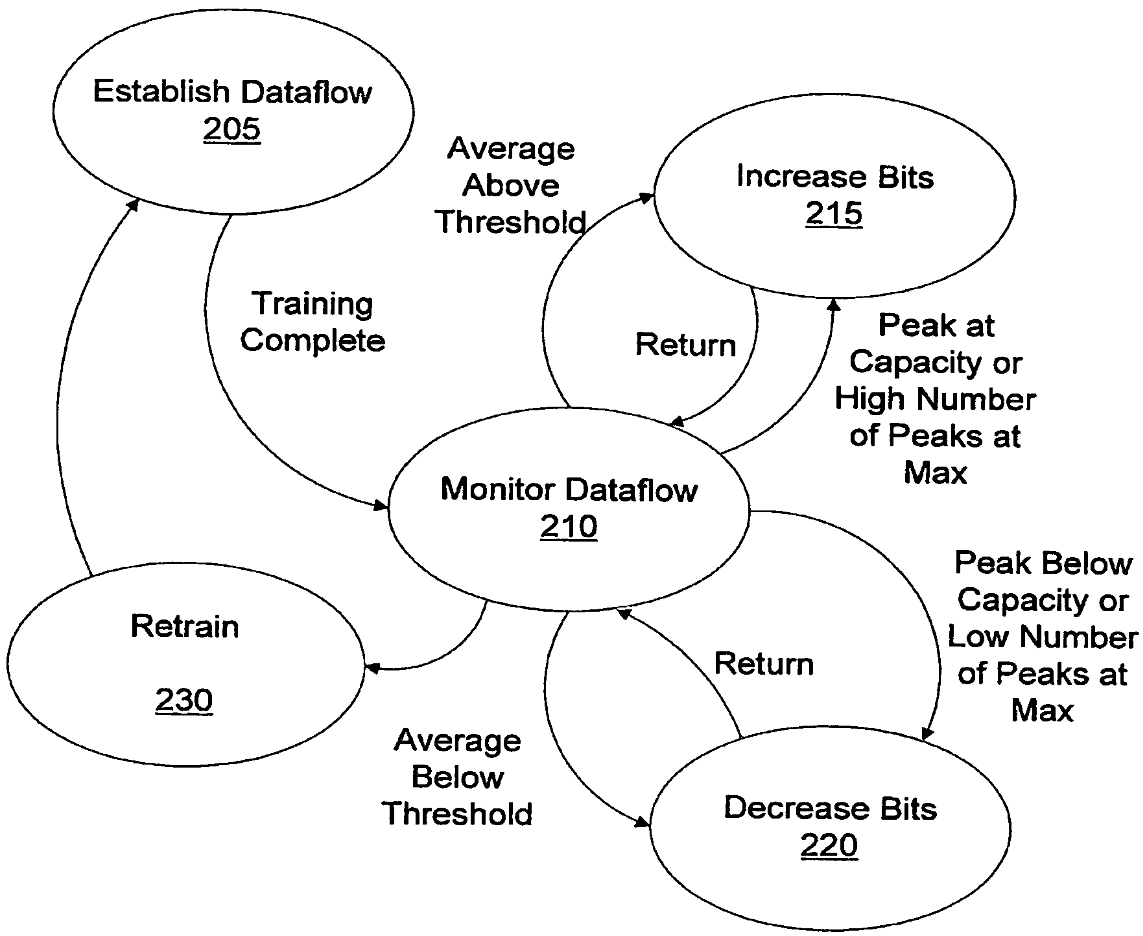
Establish Dataflow
205
Average
Above
Threshold
Increase Bits
215
Training
Complete
Return
Peak at
Capacity or
High Number
of Peaks at
Max
Monitor Dataflow
210
Peak Below
Capacity or
Low Number
of Peaks at
Max
Retrain
230
Return
Average
Below
Threshold
Decrease Bits
220

Figure 3

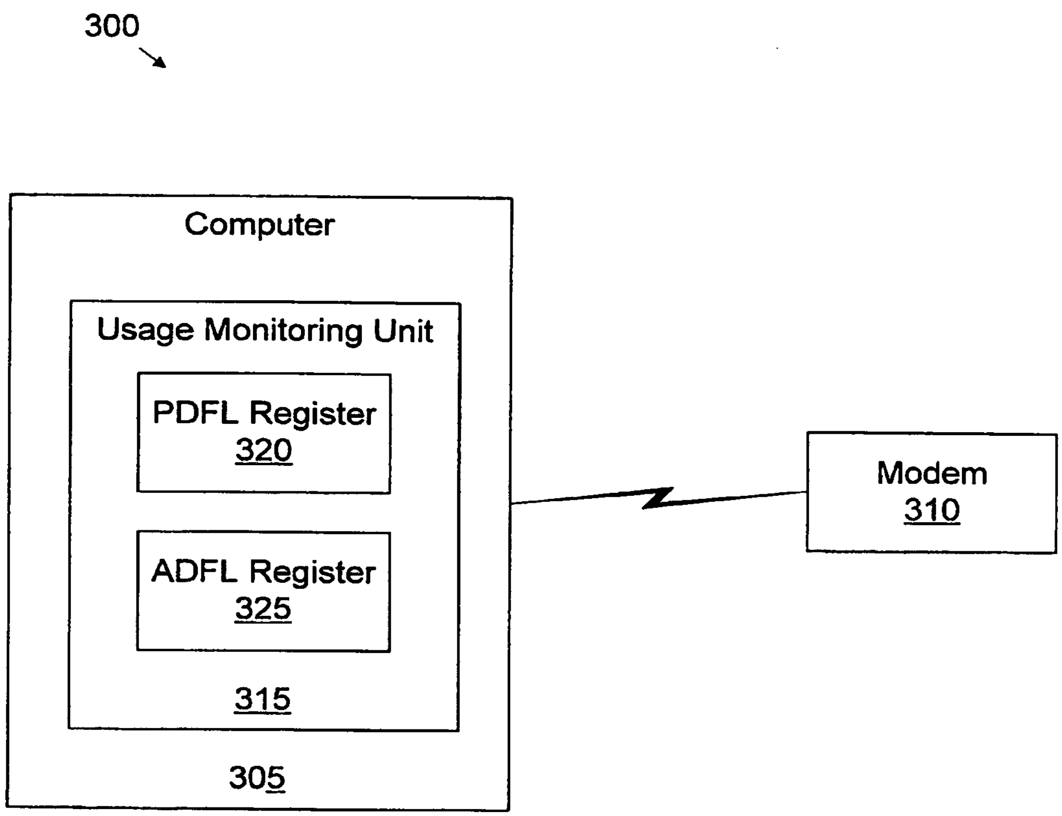
300
Computer
Usage Monitoring Unit
PDFL Register
320
ADFL Register
325
315
305
Modem
310

Figure 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/24458

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L27/26 H04Q11/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 25382 A (DSC TELECOM LP) 11 June 1998 (1998-06-11) page 47, line 16 -page 48, line 6 page 53, line 28 -page 54, line 20	1,2,6,8, 9
Y	page 86, line 15 -page 87, line 5 page 127, line 26 -page 128, line 3 ---	3-5,7, 10-13
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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2 February 2000	09/02/2000

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PCT/US 99/24458

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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